Executive Summary

The Internet Revolution, like the Industrial Revolution before it, marked a turning point. Most companies now apply internet technology to their operations, resulting in greater efficiencies. Yet with few exceptions, this digital revolution has fallen well short of its transformational potential. Today, an estimated 99 percent of things in the digital world remain unconnected.[1]

The Industrial Internet is the next frontier. It merges the physical with the digital to predict, control and create systems that produce better outcomes. Through the Industrial Internet, companies will shift from responding to events and will instead use connected machines, big data and analytics to predict and plan, resulting in large gains in industrial productivity, bottom line results and societal outcomes.

Several terms are used to describe the merging of the digital with the physical: the Internet of Things; Smarter Planet; Cyber Physical Systems; and Internet 4.0, to name a few. While each term has a different focus, the idea is the same: that better connection of machines to the Internet will transform industry and humanity.

The benefits of integrating the cyber with the physical are significant. McKinsey Global Institute estimates an annual economic impact of $2.7 trillion to $6.2 trillion by 2025[2]. Gartner estimates it will lead to a digital workforce and smart machines that will replace 1 in 3 knowledge workers by 2020[3]. General Electric estimates that the Industrial Internet could add $10 - $15 trillion to the global GDP over the next 20 years[4].

If, conservatively, the Industrial Internet achieves a 1 percent process efficiency, it will translate to billions in savings in every industry. For example, in the commercial aviation industry, a 1 percent improvement in fuel efficiency would save $2 billion a year. One well-connected factory will save millions in unplanned down time costs by using data to analyze and predict machinery failure, so it can replace failing parts before the assembly line breaks down.

Beyond its financial impact, the Industrial Internet will lead to substantial benefits to humanity. In healthcare alone, the integration of monitoring equipment with predictive analytics, will save the lives of patients in remote and onsite locations. Cleaner water, greener energy, better emergency responsiveness and more accurate forecasting of significant atmospheric events are just some of the areas to benefit populations around the world.

We are now at the threshold of the Industrial Internet, which will require key enablers and catalysts to realize its potential. To direct and manage this effort, the Industrial Internet Consortium™ (IIC) was announced in March 2014 with five founding members: AT&T, Cisco, General Electric, IBM and Intel. This open membership, not-for-profit group coordinates and connects the priorities and enabling technologies from industry, academia and government organizations. Its mission is to systematically address the complexities of the Industrial Internet, leading to faster adoption, deployments and transformational outcomes across the globe.

Industrial Innovation through the Ages

Industrial Revolution – Machines and factories led to huge new economies of scale.

Internet Revolution –Computing and communication technology brought sweeping changes to commerce and society.

Industrial Internet – Intelligent objects, systems and decision-making will result in large productivity gains, reduced operating costs and economic growth.

The Industrial Internet: Transforming Industry through the convergence of objects, minds and analytics

Looking back at history, there have been two periods of significant innovation: The Industrial Revolution and the Internet Revolution. Both transformed not only industry, but the world itself through their impact on the economy and society at large. The Industrial Revolution replaced muscle power with machines, creating sharp rises in commerce, worker productivity and living

standards. More recently, the Internet Revolution changed the use and exchange of information, enabling broad economic growth through huge productivity gains and new high-growth business models, such as online retail and globally integrated enterprises.

Now, advances in technology, communication networks and in equipment are enabling the next transformational era, one that converges the brawn of the Industrial Revolution – machines – with the brains of the Internet Revolution. Dubbed the Industrial Internet, it matches sensor-embedded machines and devices with big data to help people, objects and businesses perform significantly better. It's only now that all the components of the Industrial Internet - machines, devices, data, sensors, analytics and networks – have reached the necessary price and performance points to enable this transformation. Millions of machines, devices, infrastructure – even people – can be equipped with networked sensors that enable them to monitor their environment, report their status, receive instructions, and take action based on the information they receive.

There are other terms that describe the merger of the physical with big data and intelligence, including the Internet of Things, Smarter Planet/Smarter Cities, Cyber-Physical Systems and Internet 4.0. All are established on the same principles that the digitization of business and life will lead to major economic and social change.

The economic impact will be enormous. McKinsey Global Institute estimates an annual economic impact of $2.7 trillion to $6.2 trillion by 2025. General Electric estimates that the Industrial Internet could add $10 - $15 trillion to the global GDP over the next 20 years. Virtually every industry will benefit from the Industrial Internet, with the largest initial impact expected in industrial manufacturing, healthcare, energy management and in the public sector.

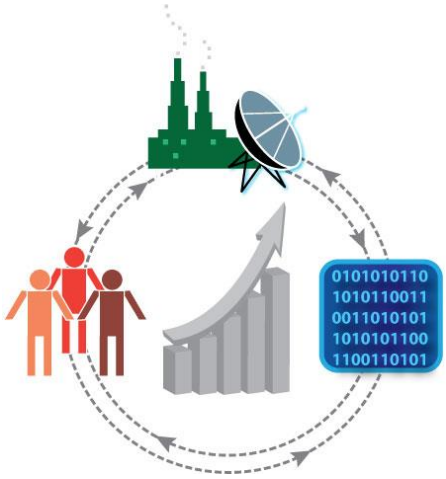
Many of the economic gains will be through newfound efficiencies. Today, it is difficult for companies to squeeze out additional productivity from high performance equipment and lean staffing levels. The deployment of intelligent, connected devices will let decision makers see and adjust the status and flow of goods or materials through its supply chain. Gartner estimates that this convergence will lead to a digital workforce and smart machines that will replace 1 in 3 knowledge workers by 2020. For example, an intelligent, connected device can send an alert for preventative maintenance before a machine breaks down, eliminating unscheduled factory downtime which subsequently reduces costs and improves productivity. Decentralized, personalized intelligence can be sent directly to mobile devices for action in the field. A store manager could decide to increase or decrease inventories based on an updated weather forecast, boosting customer loyalty and the bottom line.

Society as a whole will likewise benefit from the Industrial Internet. In addition to the projected economic boost, the Industrial Internet will lead to improvements in healthcare, infrastructure, public safety, municipal services and in the environment. Remote monitoring will improve the lives of people with

chronic diseases while simultaneously driving down healthcare costs. Smart power grids and water systems decrease greenhouse gas emissions and waste of natural resources. Cities and towns will improve their infrastructure, traffic patterns, sanitation collection and other services. Public safety will increase through advanced video analytics and on demand deployment of additional resources to at-risk areas.

How The Industrial Internet Works:

Machines or devices collect performance data, which is aggregated across a network and analyzed against a database of millions of past performance data, and the assessment is displayed via a dashboard. Decision makers, field workers or the devices themselves can react to the new intelligence in real-time or near real time, for more efficient and effective decision making.



Here's a closer look at pre- and post-Industrial Internet scenarios:

Industrial Internet in action: Commercial Aviation Scenario

For business traveler, here's a scene that is repeated all too often:
You rush out of an important meeting to fight your way through rush-hour traffic, only to find that your flight is delayed due to a mechanical problem. You wait out the delay by calling customers to complete the details better carried out in person.

Through the Industrial Internet, there will be fewer unplanned mechanical failures, less costly repairs due to better preventative maintenance, improved labor scheduling, safer equipment and more on-time flights in commercial aviation. The cost savings alone are tremendous. According to General Electric, commercial jets spend $60 billion annually on maintenance, 43 percent of which is spent on engine maintenance alone[5]. Every 1 percent improvement in engine maintenance efficiency saves $250 million in costs. In addition, airlines will gain more loyal customers as a result of fewer flight delays, and businesses will realize higher workforce productivity across the board.

In an Industrial Internet-enabled world, the scenario above plays out differently:

Earlier that day, as the same plane touched down in another city, it triggered an event to wirelessly transfer hundreds of flight performance data points to the ground

maintenance crew. As the plane begins to taxi to the gate, a technician views the updated dashboard, which has analyzed the data and alerted the technician that seven loose bolts need tightening on the underbelly of the plane. The technician is already aware that he will be replacing a turbo fan on the right wing. Two days ago, software had compared the jet engine's data against patterns created from thousands of other flights. These 'predictive analytics' recommended replacing it, which triggered an automatic part order, which was flown in the evening before. It also created an updated labor schedule. When the plane reached the gate, parts and personnel were ready to install the parts, to pre-empt an emergency repair in the future and extend the engine life.

In the meantime, your smartphone had automatically connected with the airline and was aware that there would be a 20-minute delay, which pushed back your departure time, allowing you extra time to wrap up your meeting. En route to the airport, automatic traffic feeds and sensors in the pavement let you know about the breakdown ahead, which triggered a shift in traffic flow to minimize delay. You arrive at the airport having successfully completed your meeting and ready to board.

The Industrial Internet in Healthcare:

In healthcare, the Industrial Internet will delivers far more than cost savings, as in this scenario:

It's a busy day on the hospital ward. The oxygen saturation meter on the patient in Room 507 has beeped twice, but the experienced – and busy - nurses know that about 20 percent of the time, the meters give false readings. A minutes later, it beeps again. As a nurse gets up to check, she gets stopped in the hallway and has a quick conversation before continuing to Room 507. When she gets there, she sees that the patient's respiratory levels have fallen and a code blue alarm is signaled.

Today, basic medical devices, such as oxygen meters and respiratory monitors, operate in silos. In the future, these and other devices will be connected, leading to much better outcomes for patients, both in hospital and in remote locations. Here's how this scenario will fare in a scene from the not-too-distant future:

It's a busy day on the ward. The oxygen saturation meter on the patient in Room 507 sounds an alert. Integrated with the respiration flow meter, it signals a sharp beep that means both the oxygen and the respiratory levels are falling. The RN and doctor rush into the room to administer aid. The patient, now stabilized, goes back to sleep and the staff resumes their morning bed checks.

This simple improvement, enabled by common industrial internet platforms, will have major repercussions as other "small" connections are made between things.

Using the Industrial Internet, medical equipment can be monitored, modeled and remotely controlled and automated, driving down costs and providing home-bound patients with targeted, quality care. Intelligent machines will help to drive new efficiencies and drive down costs. PriceWaterhouseCoopers estimates that the Industrial Internet can help drive down annual healthcare costs by roughly 25 percent, or about $100 billion a year[6].

Above and beyond improved medical efficiencies, the Industrial Internet will result in fewer medical errors, in improved quality of life and in actual saving of life. The Institute for Healthcare Improvement estimates there are 15 million incidents of medical harm each year[7]. In its landmark report, *To Err Is Human*, the US Institute of Medicine stated that up to 98,000 Americans died in 1999 as a result of preventable medical errors in US hospitals and up to one million more patients experienced some type of preventable error.[8] Newer studies suggest that the rate of preventable harm may be up to ten times higher than IOM estimates.[9]

In the future, the Industrial Internet will help doctors to make more informed decisions on specific patient conditions, leading to safer procedures. In addition, a healthier workforce means fewer sick days and higher productivity across the board.

Addressing the Challenges and Opportunities through the Industrial Internet Consortium

There are clear opportunities for growth through the Industrial Internet, but there are challenges as well, particularly around privacy and security. Legislators and businesses alike need to resolve how and where the data will be used, especially as sensors are introduced into the lives of consumers. These need to be addressed before widespread adoption of the Industrial Internet in order to protect the rights and privacy of individuals while enabling the benefits of Industrial Internet applications.

In order to systematically harness all the challenges, initiatives and opportunities of the Industrial Internet, the independently-run Industrial Internet Consortium™ (IIC) was announced in March 2014. Its mission is to lead and coordinate the disparate efforts of industry, academia and the government around the Industrial Internet. This not-for-profit, open-membership group was founded under the leadership of AT&T, Cisco, General Electric, IBM and Intel. The IIC will drive down barriers to entry to the Industrial Internet by establishing and influencing common architectures, interoperability and open standards for integrating devices and machines with people, processes and data. Among its priorities are to create best practices, test beds and case studies that transform the collective vision of the Industrial Internet into real-world applications.

The IIC is an open membership group. IIC members work in focused task forces to influence the requirements development, technology adoption, and future direction of the Industrial Internet. Members also have the opportunity to participate in research projects and test bed activities. There are five levels of membership: Founder; Industry >$50 million; Industry <$50 million; Academic/Nonprofit; and Government Agency.

Governance for the IIC is provided by its Steering Committee, comprising nine representatives affiliated with IIC member companies, plus the Executive Director. Richard Soley, Chairman of the Industrial Internet Consortium and the

Object Management Group, is the Executive Director and ex-officio member of the Steering Committee. Administrative, technical and marketing oversight is provided by dedicated IIC staff from Object Management Group, the nonprofit computer industry standards consortium.

On the technical front, the IIC works to reduce duplication of effort through coordination of the development of common architectures and platforms. This will cover identification and location of devices, transport of data between them, control and integration of collections of heterogeneous devices, data extraction and storage plus data and predictive analytics. The challenge for the IIC is to ensure that these efforts come together into a cohesive whole. There is a great deal to do--and a great deal already being done.

Through its independent efforts, the IIC will further the development, adoption and wide-spread use of interconnected machines, intelligent analytics and people at work, leading to the full realization and promise of the Industrial Internet.

Industrial Internet Consortium Mission Statement:

To accelerate growth of the Industrial Internet by coordinating ecosystem initiatives to connect and integrate objects with people, processes and data using common architectures, interoperability and open standards that lead to transformational business outcomes.

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[1]Source: Cisco Systems
[2] McKinsey Global Institute, May 2013
[3] Gartner Symposium ITXpo October 2013
[4] General Electric: Industrial Internet, Pushing the Boundaries of Minds and Machines, November 2012
[5] Ibid
[6] PriceWaterhouseCoopers Health Research Institute 2010
[7]Institute for Healthcare Improvement: Campaign – FAQs, Institute for Healthcare Improvement
[8] Levinson, DR, "Adverse Events in Hospitals: National Incidence Among Medicare Beneficiaries," Office of Inspector General, Department of Health and Human Services (Nov. 2010)
[9]Classen, DC, *et al*., "'Global Trigger Tool' Shows That Adverse Events in Hospitals May Be Ten Times Greater Than Previously Measured," *Health Affairs,* Project Hope, Bethesda, MD (Apr. 2011)